Processes analysis in the Channel of Toulon

Model / Measures comparison

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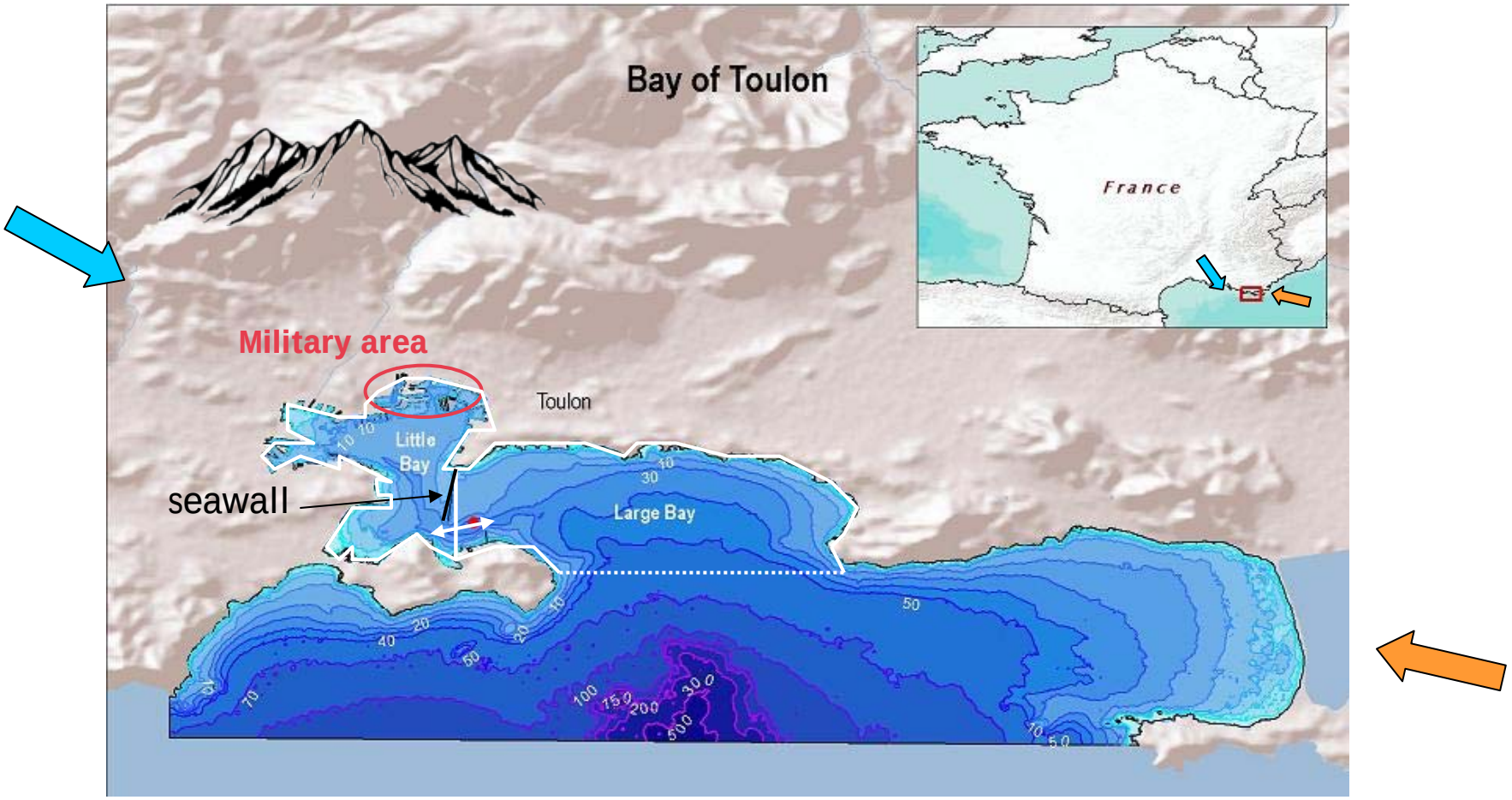
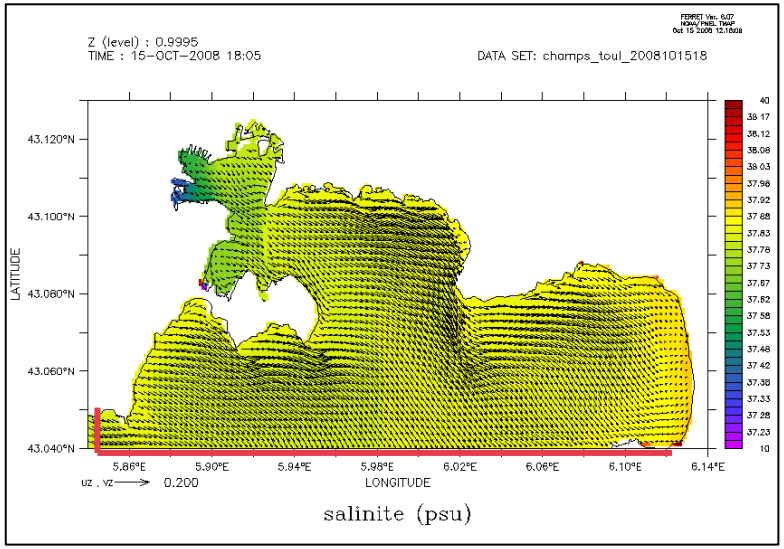
Study area


Bay of Toulon
France
Military area
Toulon
Little Bay
Large Bay
seawall

TOUL Model (Duffa,C. et al. 2011)

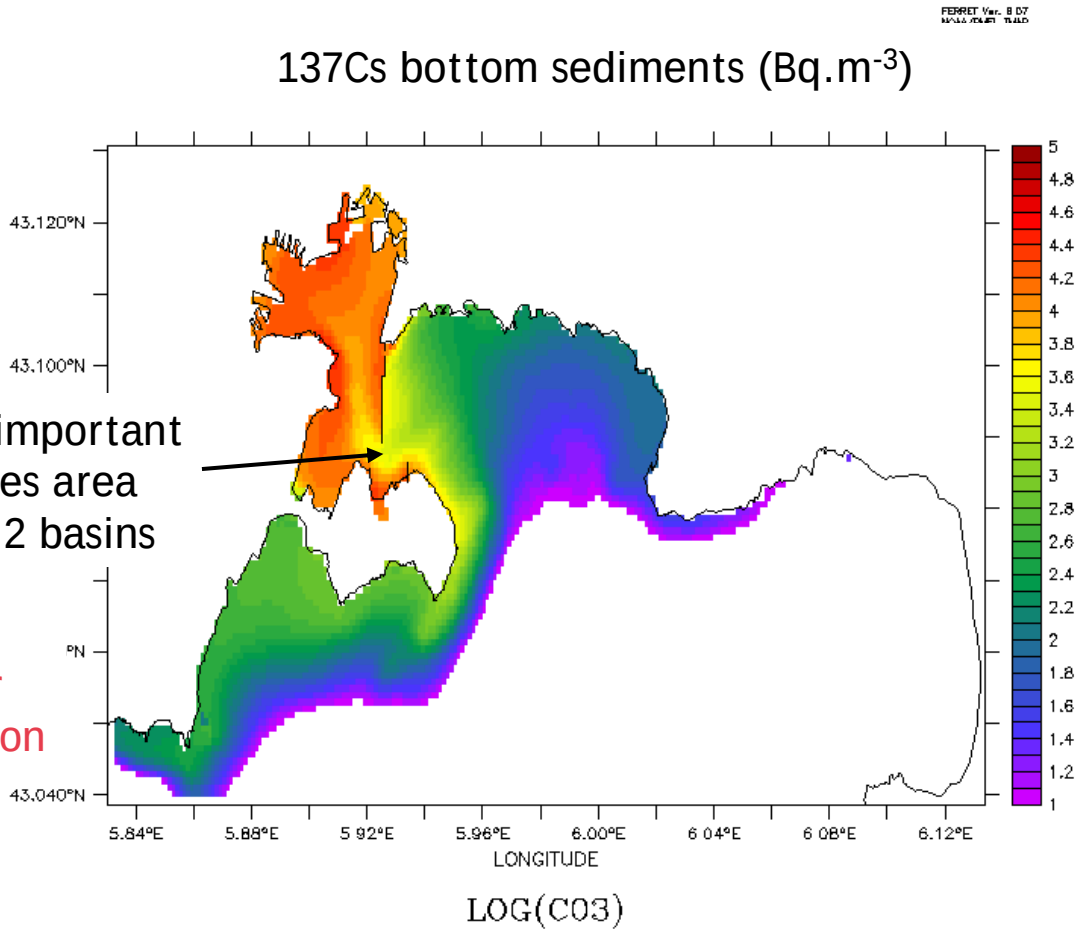
MARS-3D (Model for Application at Regional Scale, IFREMER)
Primitive equations (hydrostatic assumption and Boussinesq approximation)
Arakawa C grid
sigma coordinate



OBC = MENOR (Ifremer)

- 243*100 meshes
- Horizontal resolution 100m
- 30 vertical sigma layers
- Coupling
  - Hydrodynamic
  - Sediment transport
  - Contaminant behavior
- Meteorological forcing = MM5
- Oceanographic forcing = MENOR (Ifremer)

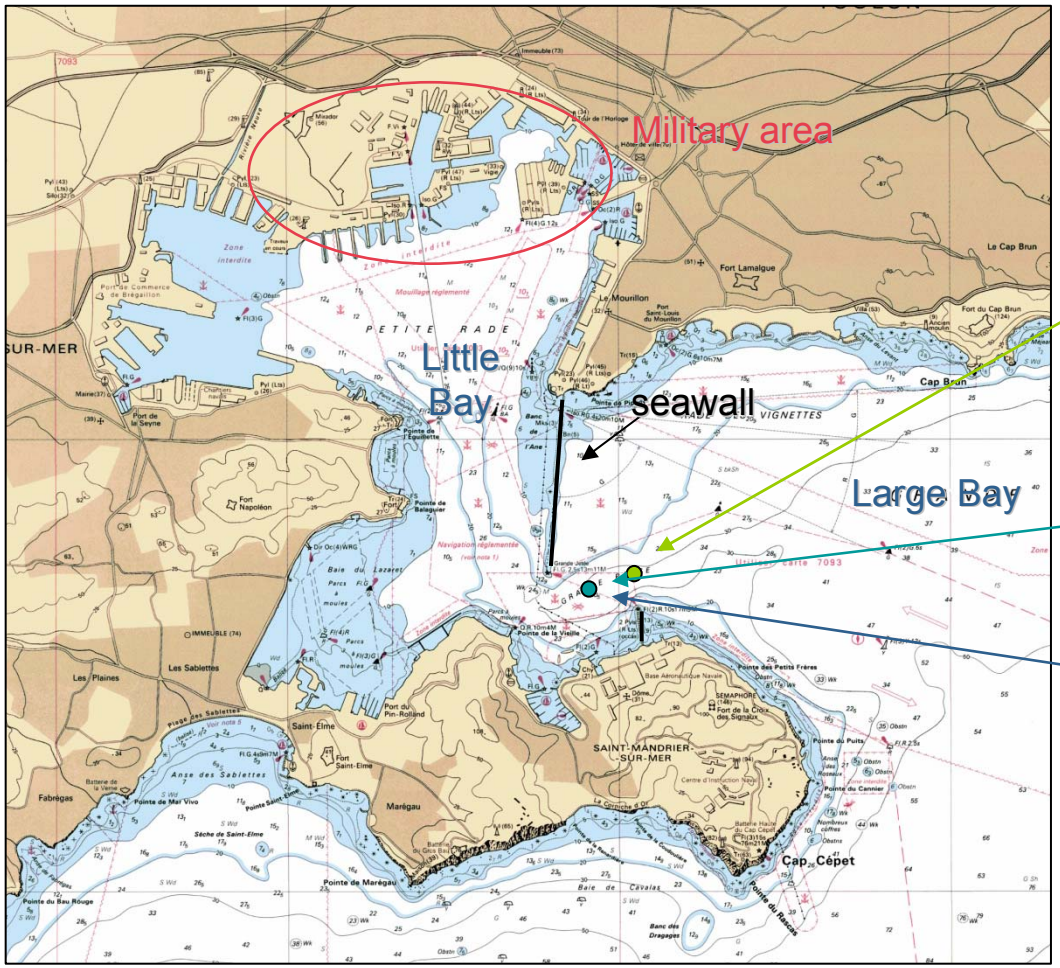
Model TOUL (Duffa,C. et al. 2011)



Channel : important exchanges area between 2 basins

Strategic location for instrumentation

Instrumentation



ADCP : 1 year

June – October 2009 (32m)

Trawling!

November 2009 – June 2010 (30m)

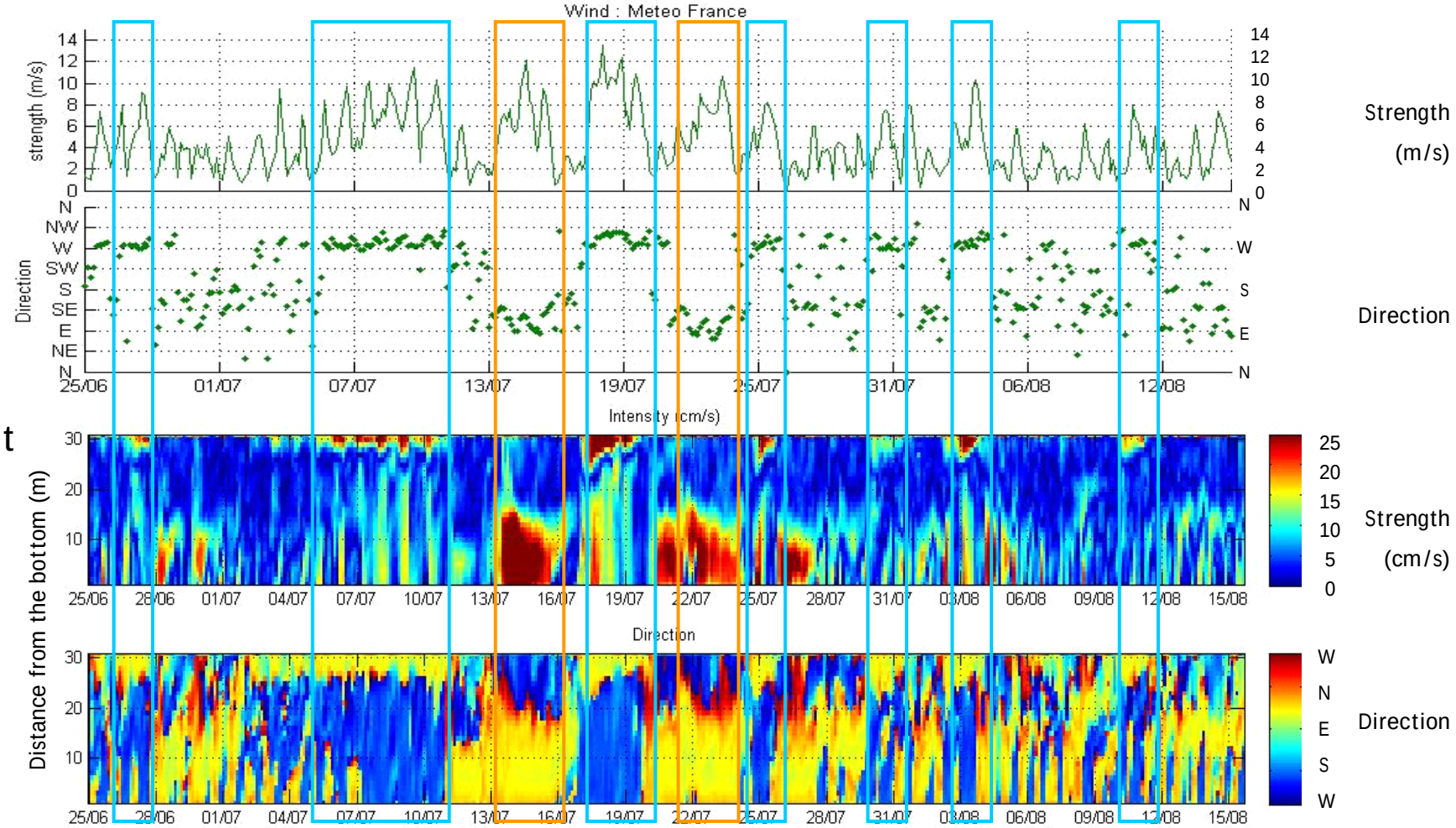
9 CTD casts June – August 2010

Results

Summer 2009

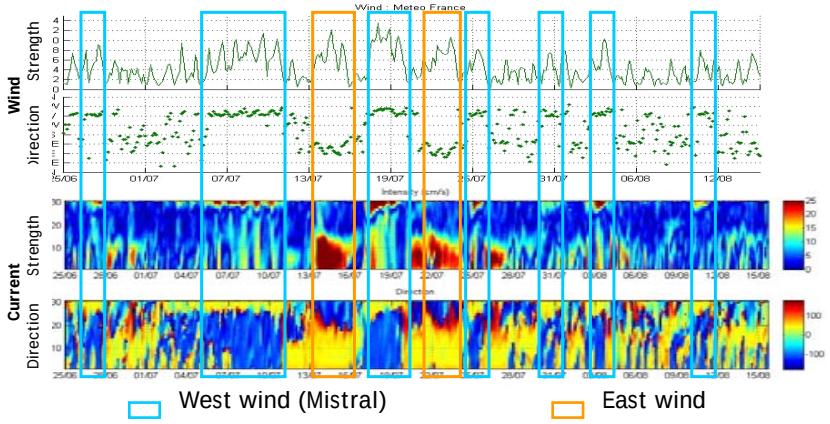
Wind

Current



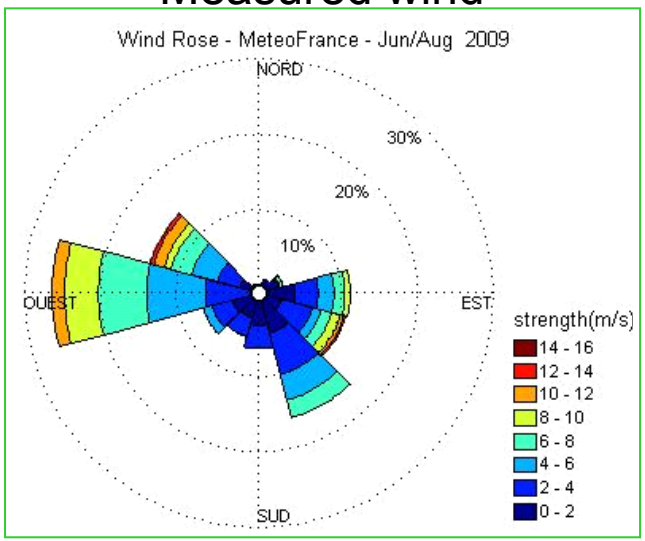
Results

Summer 2009

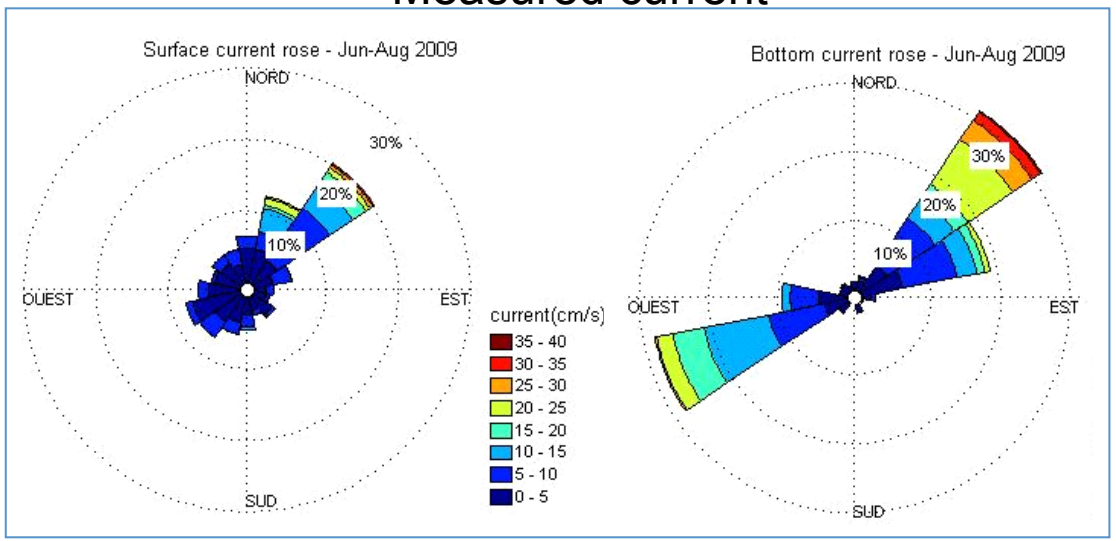


- strong surface current : NE → Mistral blows
- strong bottom currents : SW ; NE : strongest → east wind
- wind direction changes → currents' reversal occurs within a day

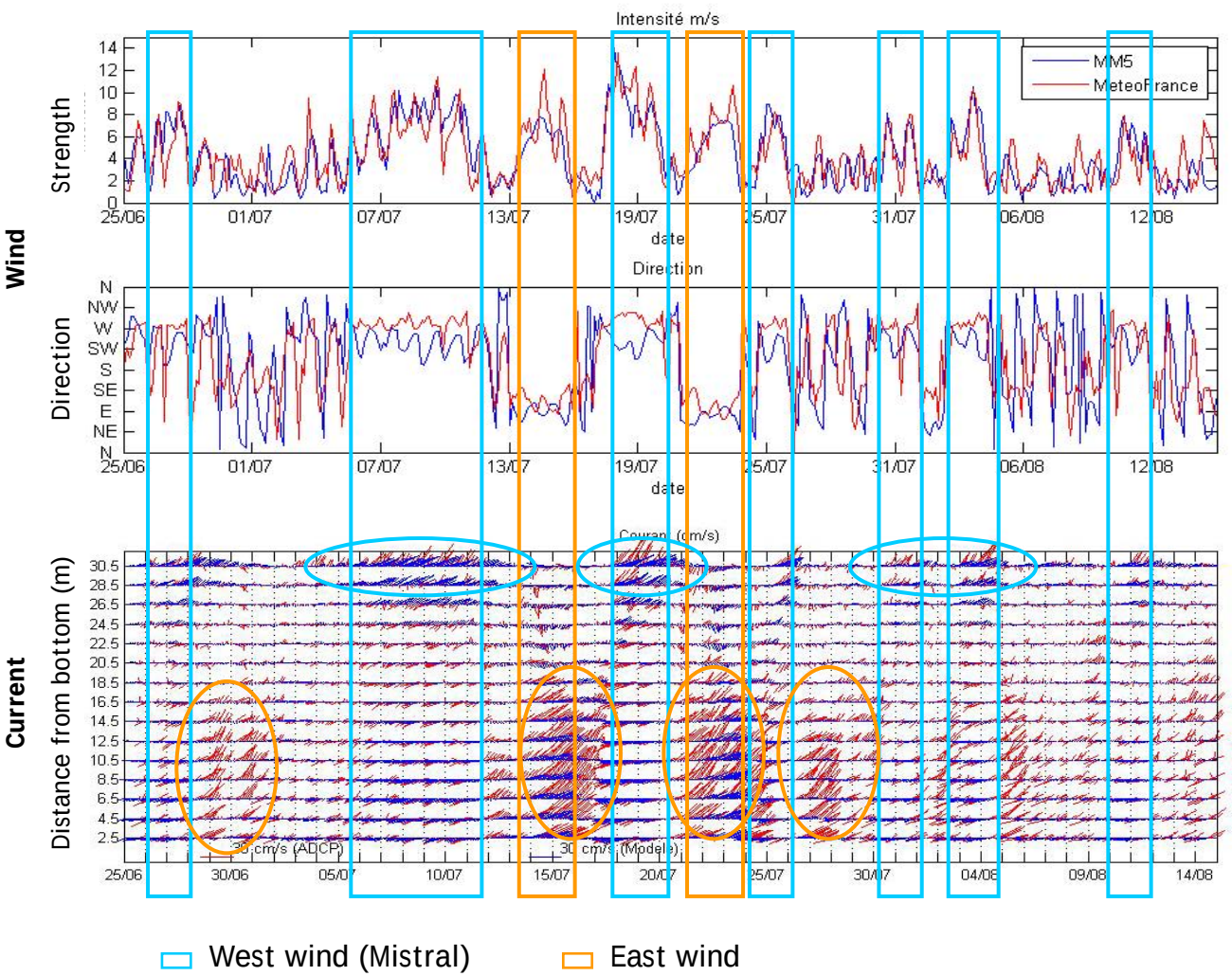
Measured wind



Measured current



Model / ADCP measures comparison



Summer 2009

Recorded (MeteoFrance)

Model results (MM5)

Current strength underestimated

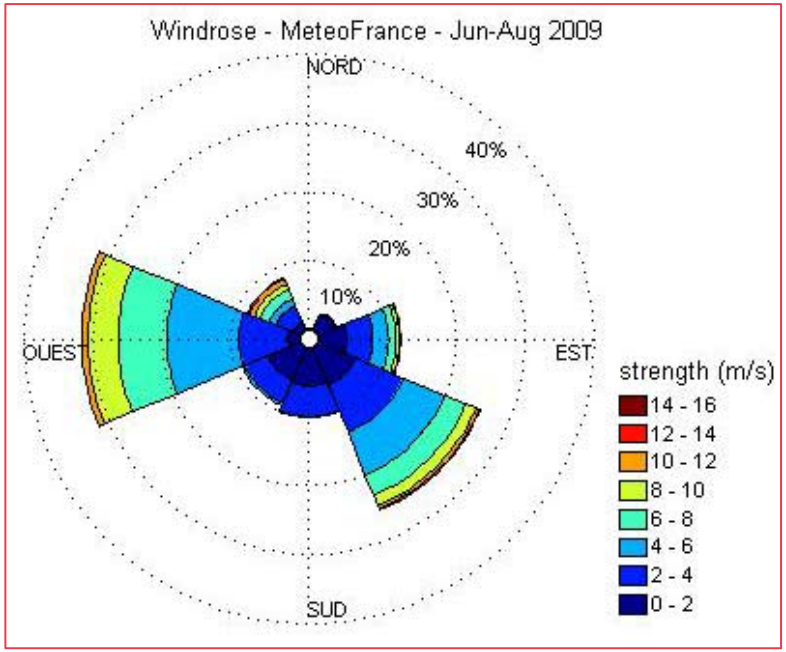
Recorded (ADCP)

Model results (MARS3D)

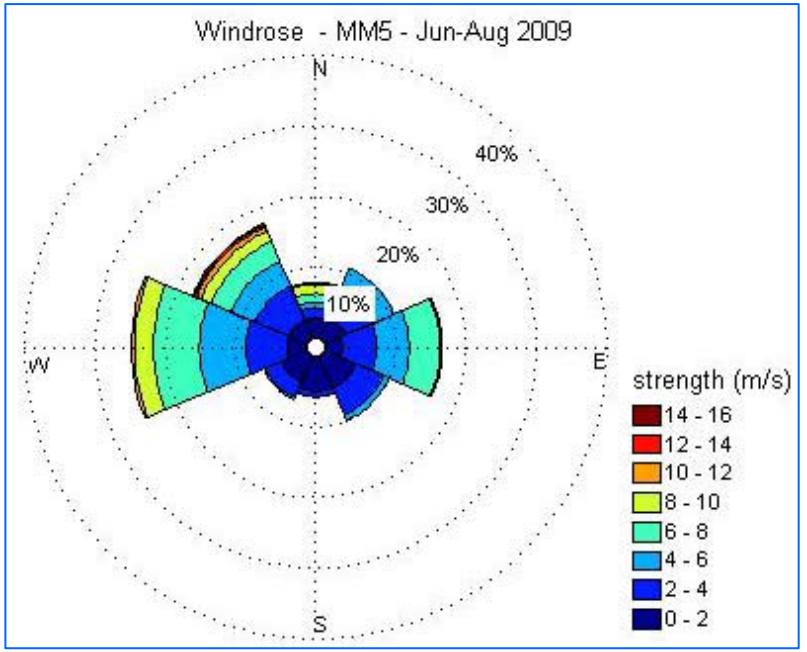
Wind analysis

Summer 2009

Measured wind



Modeled wind

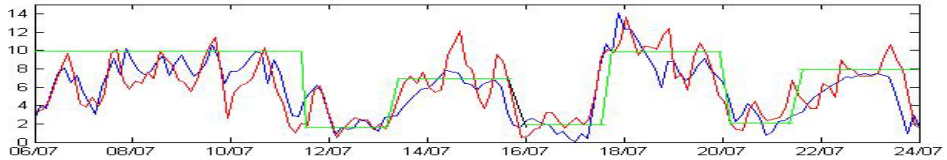


Strong wind event (>5ms^{-1})	MeteoFrance	MM5
West	mean = 7.4 ; std=1.8	mean = 5.3 ; std=3.2
East	mean = 7.1 ; std=1.7	mean = 4.2 ; std=2.3

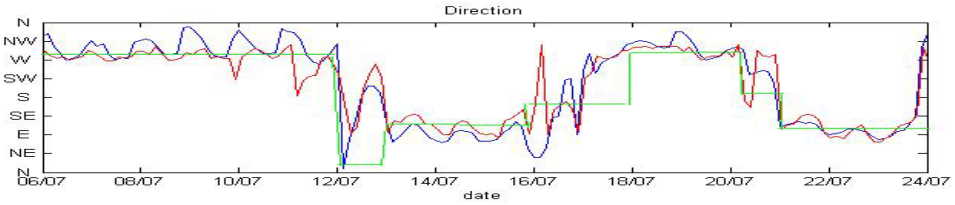
Modification of model parameters

Wind

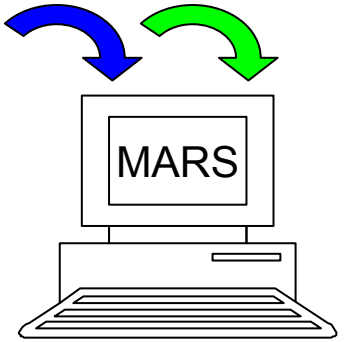
Strength (ms^{-1})



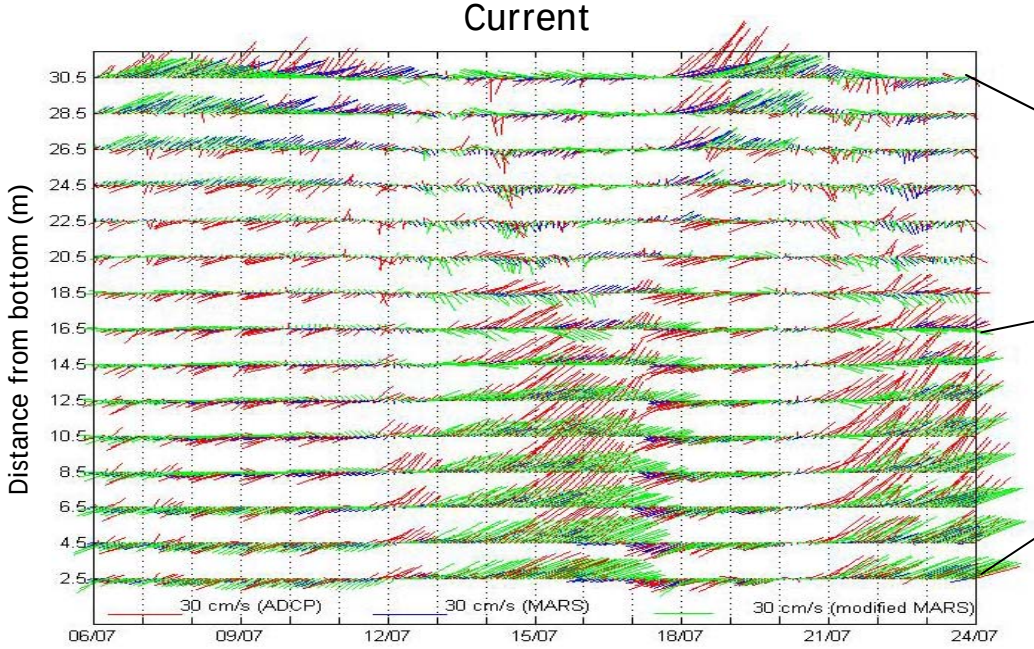
Direction

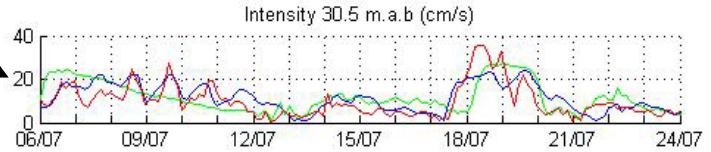


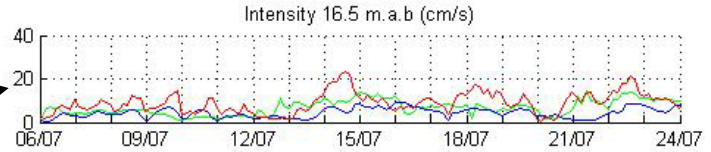
MeteoFrance
MM5
Idealized

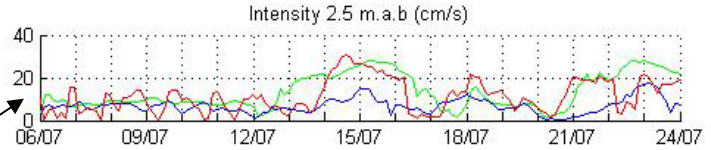


Current





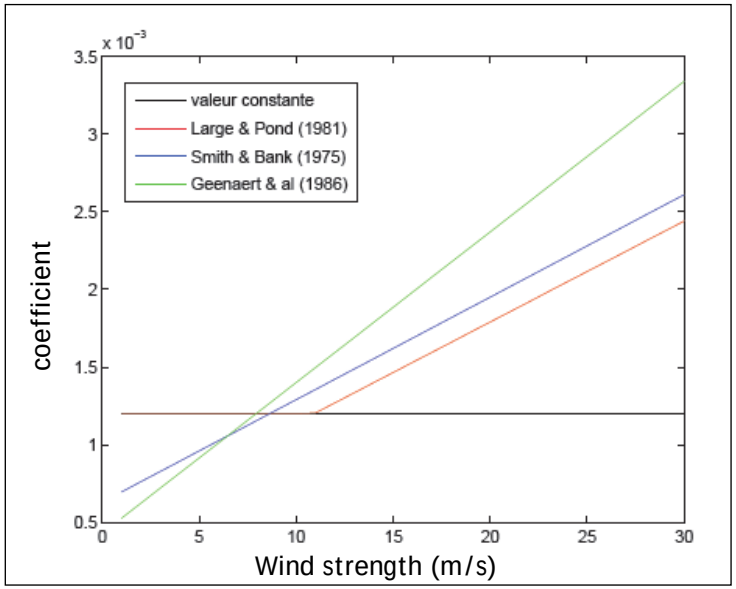




Modification of model parameters

Same meteorological forcing : MM5

Surface drag coefficient



(Schaeffer, 2010)

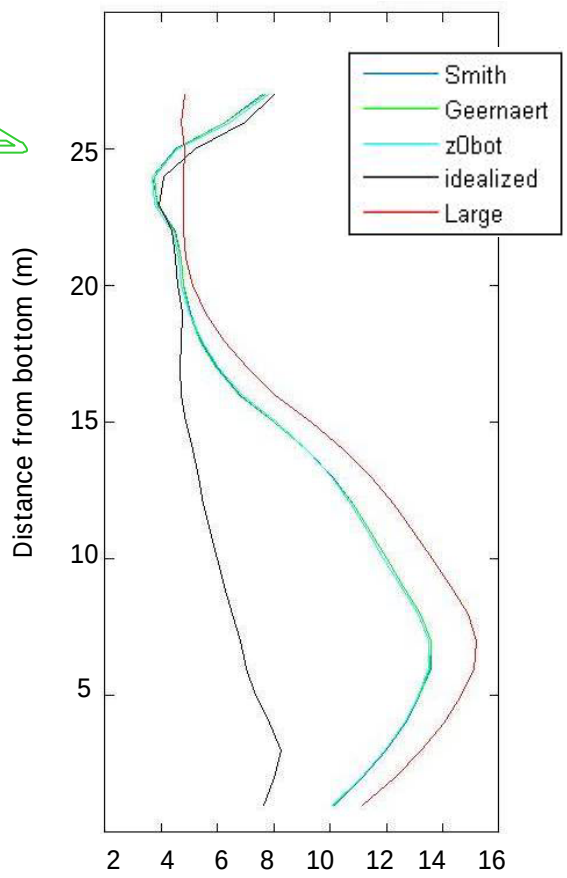
$Cd = 10^{-3}(0.49+0.065U)$

if $U>10ms^{-1}$, else $Cd=1.2*10^{-3}$

$Cd = 10^{-3}(0.63+0.066U)$

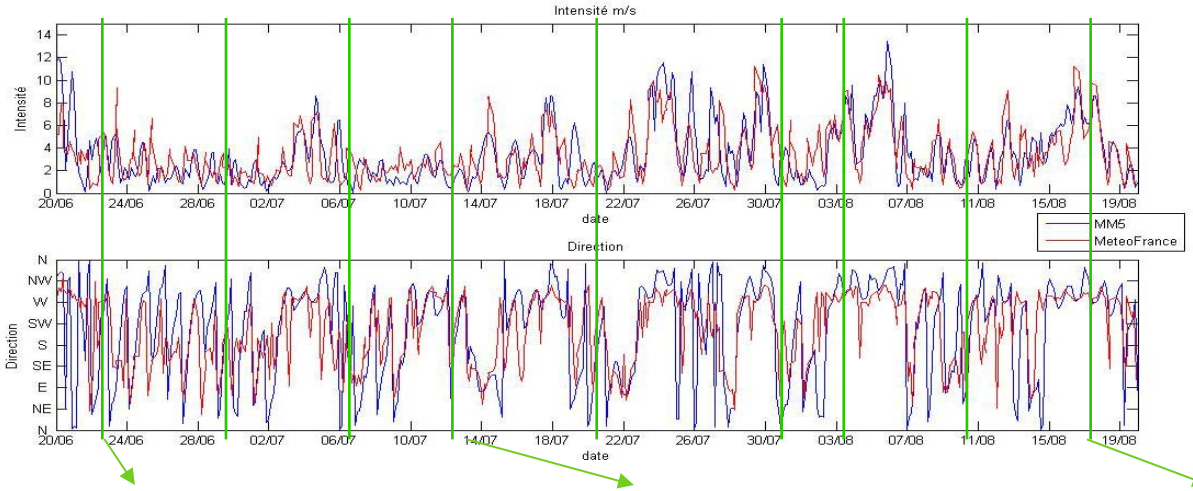
$Cd = 10^{-3}(0.43+0.097U)$

Computed/recorded currents RMSE



Surface drag coefficient impact < Meteorological forcing impact

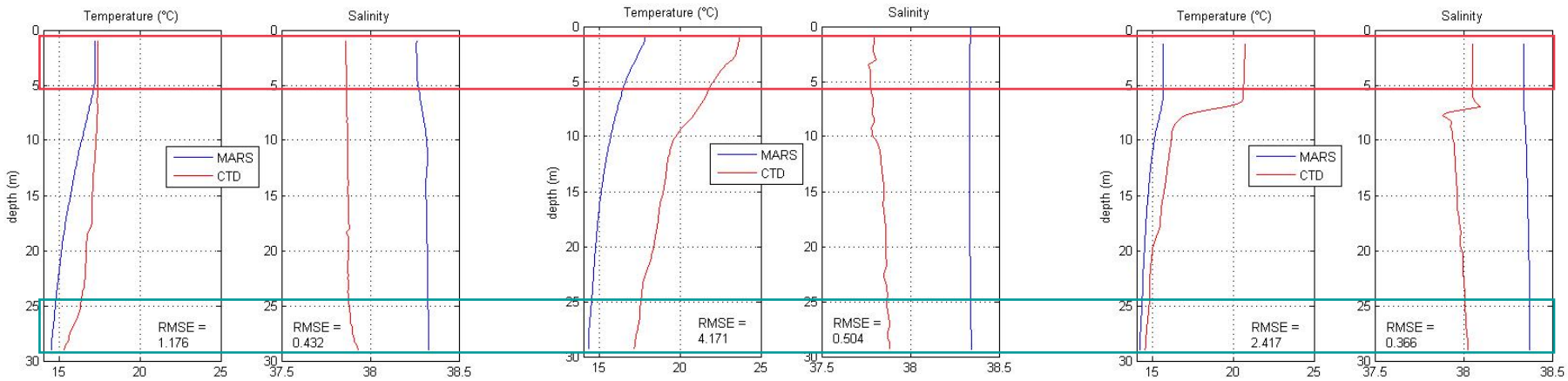
Model / CTD measures comparison



Summer 2010

RMSE temp = 3.651

RMSE sal = 0.442



RMSE temp 5 first m. = 4.386

RMSE sal 5 first m. = 0.421

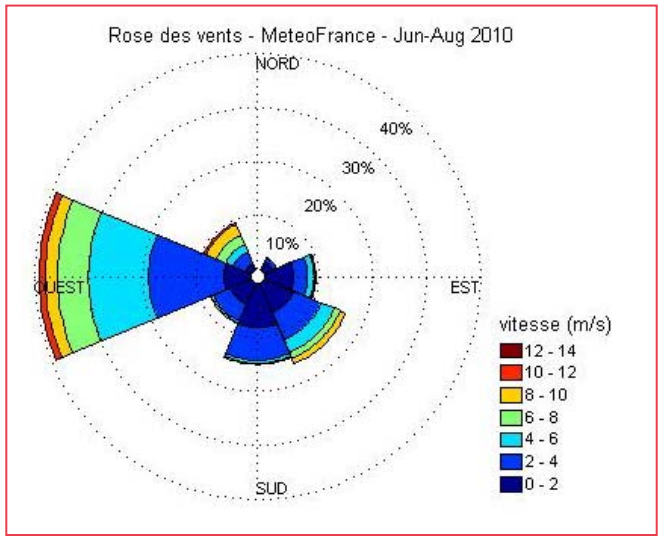
RMSE temp 5 last m. = 2.470

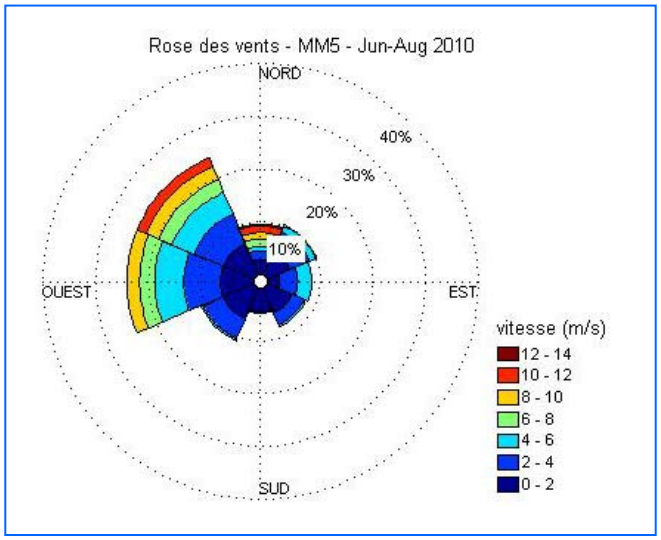
RMSE sal 5 last m. = 0.439

Meteorological data comparison

Summer 2010

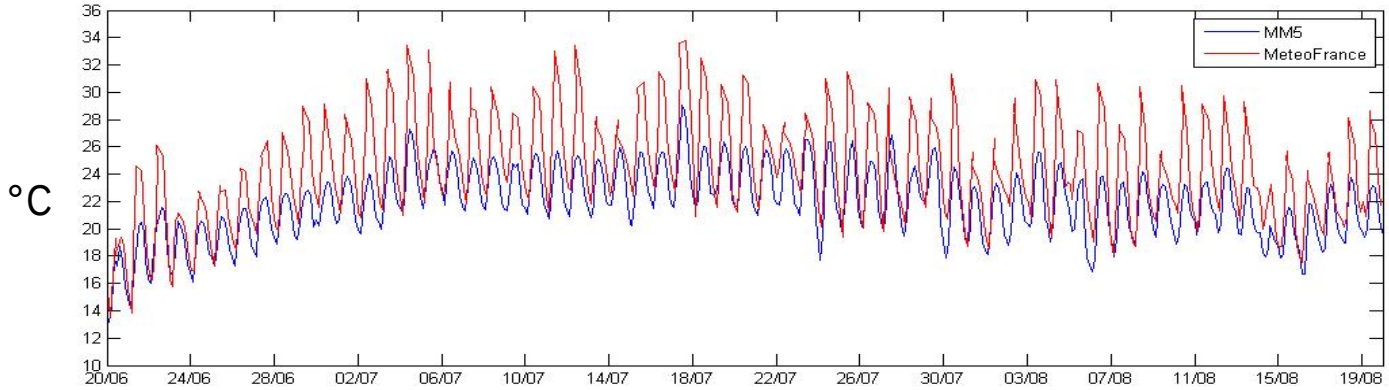
Measured wind





Computed wind

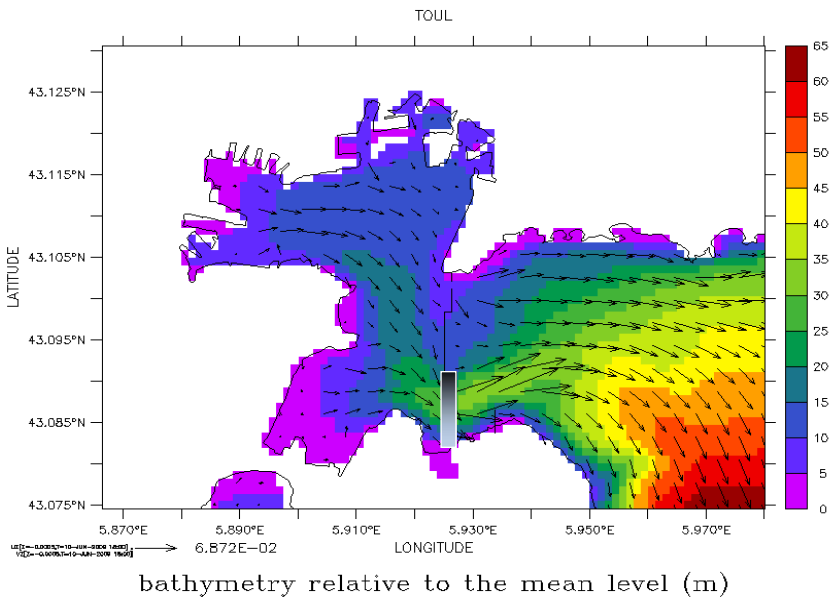
Air temperature comparison



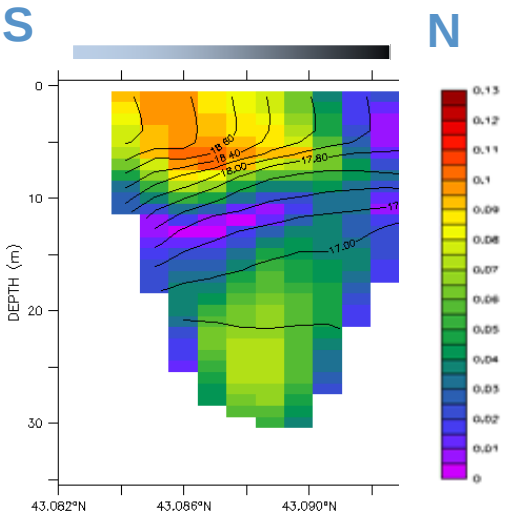
Mean=21.86°C

Mean=24.04°C

Flow analysis



bathymetry relative to the mean level (m)



South – North profile : currents' intensity and isotherms

- Simplify flow balance through the channel (Inflow : u < 0 , outflow u > 0)
- Mean renewal rate : $\frac{\text{Inflow}}{\text{Little Bay volume}}$ = 9/month
- Mean renewal time : $\frac{\text{Little Bay volume} * \text{period}}{\text{inflow}}$ = 0.11month

⇩

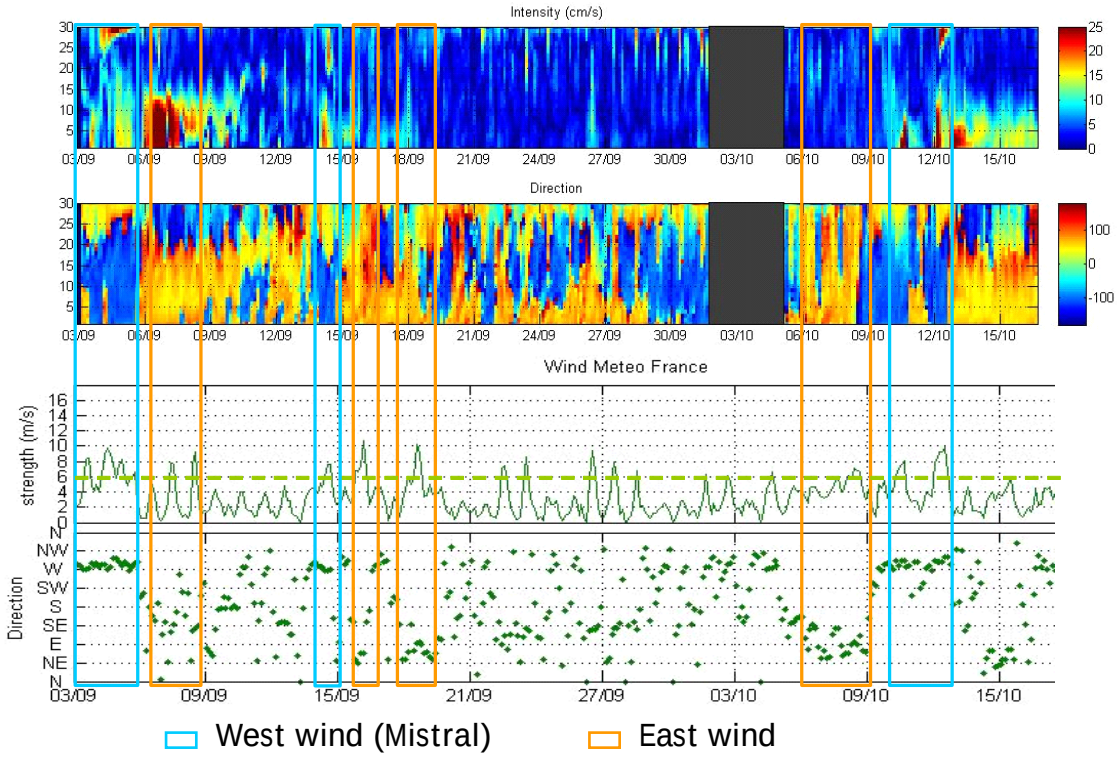
residence time ~ 3days

Strongly wind-dependent :
summer ~ 4.5 days
winter ~ 2.5 days

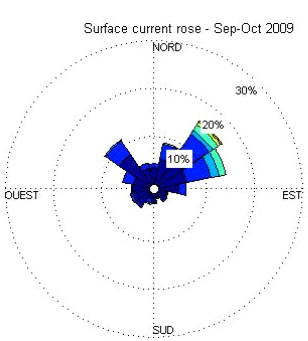
Conclusion

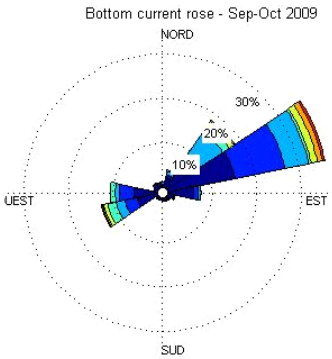
- Circulation strongly dependent and responsive to meteorological forcing
- Computed/recorded current data comparison : model reliable
- Accuracy depends on meteorological forcing
- Post accidental management tool : important to ripen meteorological forcing to simulate RN dispersion
- Real meteorological forcing
- Temperature/salinity comparisons (summer + winter)
- Tide impact while calm weather period?
- Little channel (~40m wide, ~10m deep)
- Suspended matter discharge estimation
- Calibration + validation sediment transport

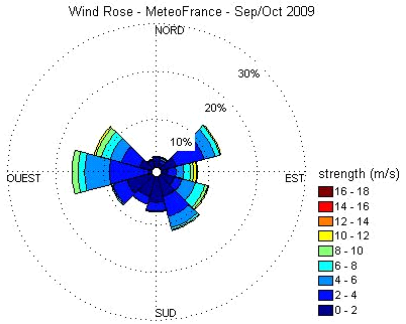
Results



Fall 2009



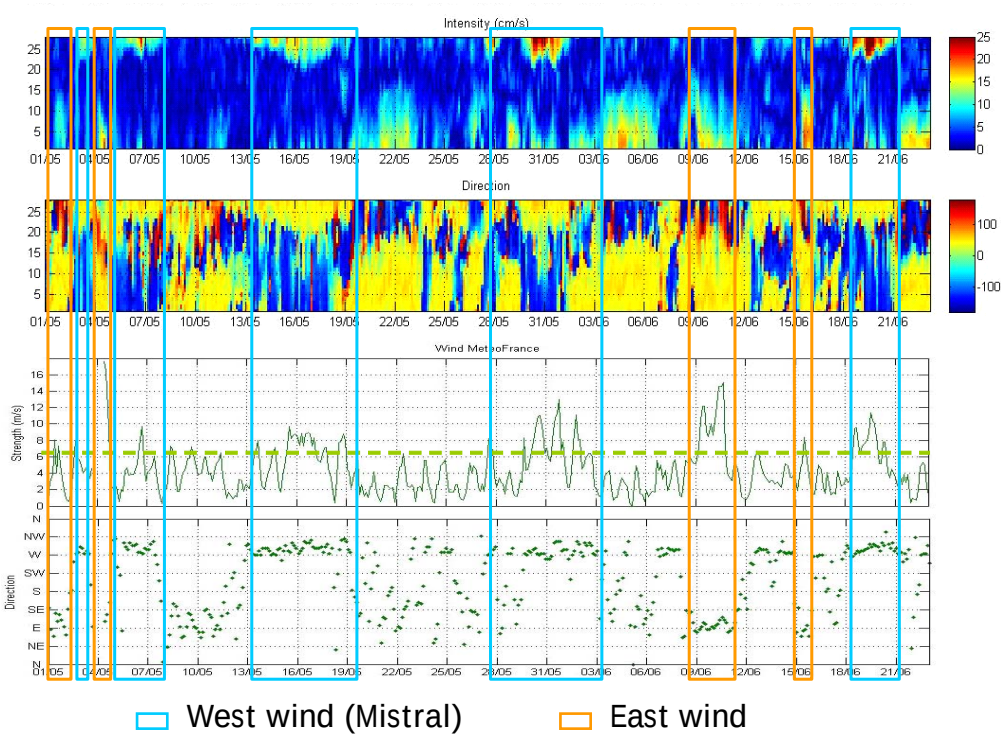


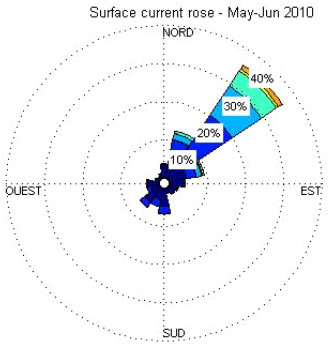


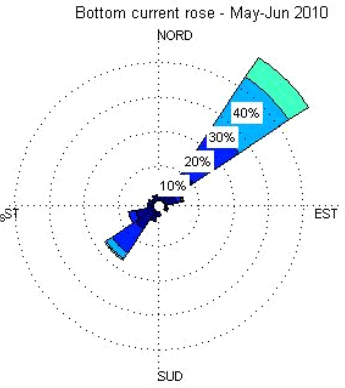
- 1 direction surface current is strong : NE → Mistral blows
- 2 directions bottom currents : NE , SW
- calm period
- wind direction changes → inversion occurs within a day

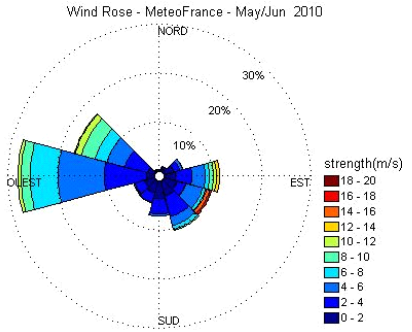
Results

Spring 2010





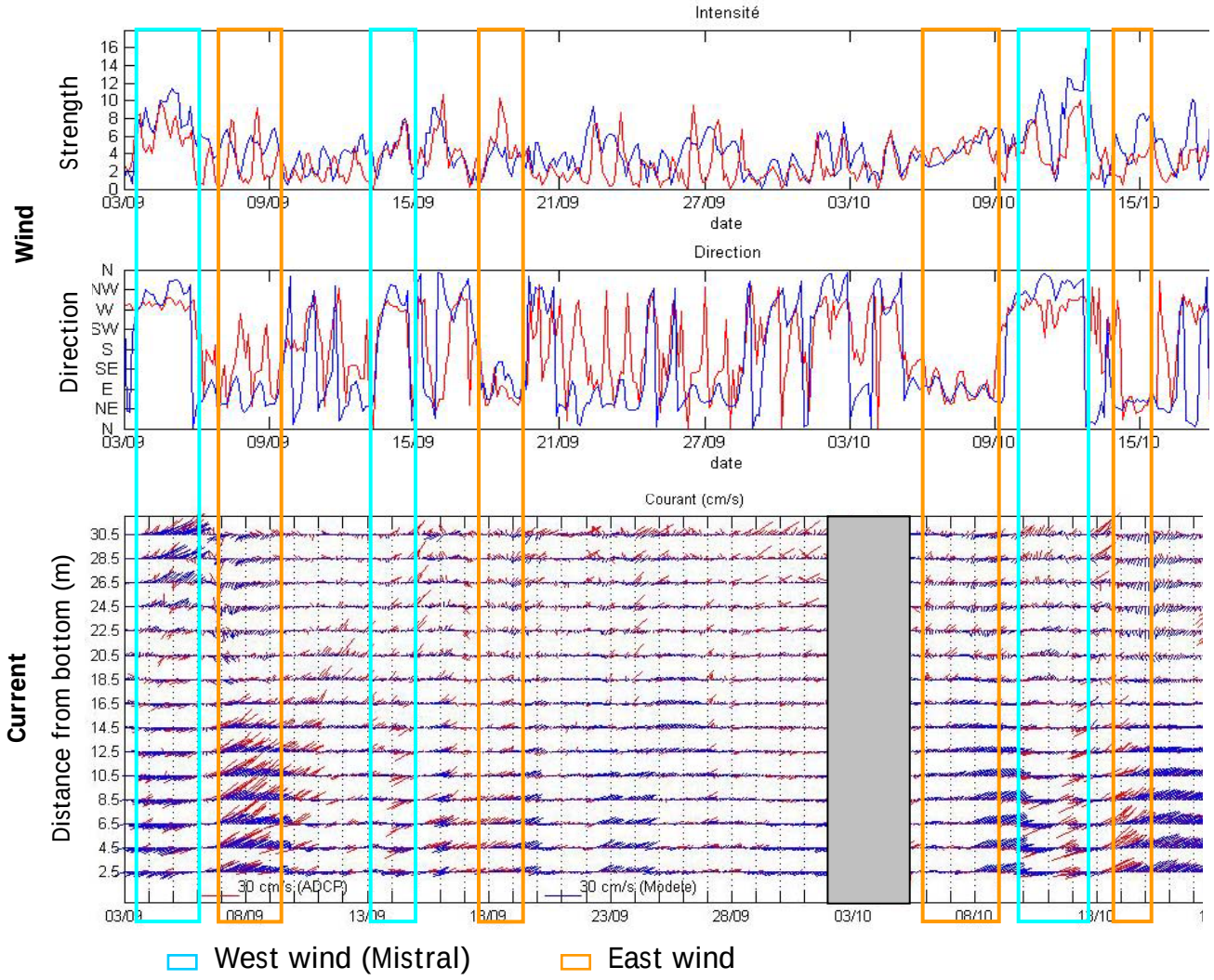




- 1 direction surface current is strong : NE → Mistral blows
- 2 directions bottom currents : NE , SW
- strong bottom current : east wind
- wind direction changes → inversion occurs within a day

ADCP's location has changed

Model / ADCP measures comparison



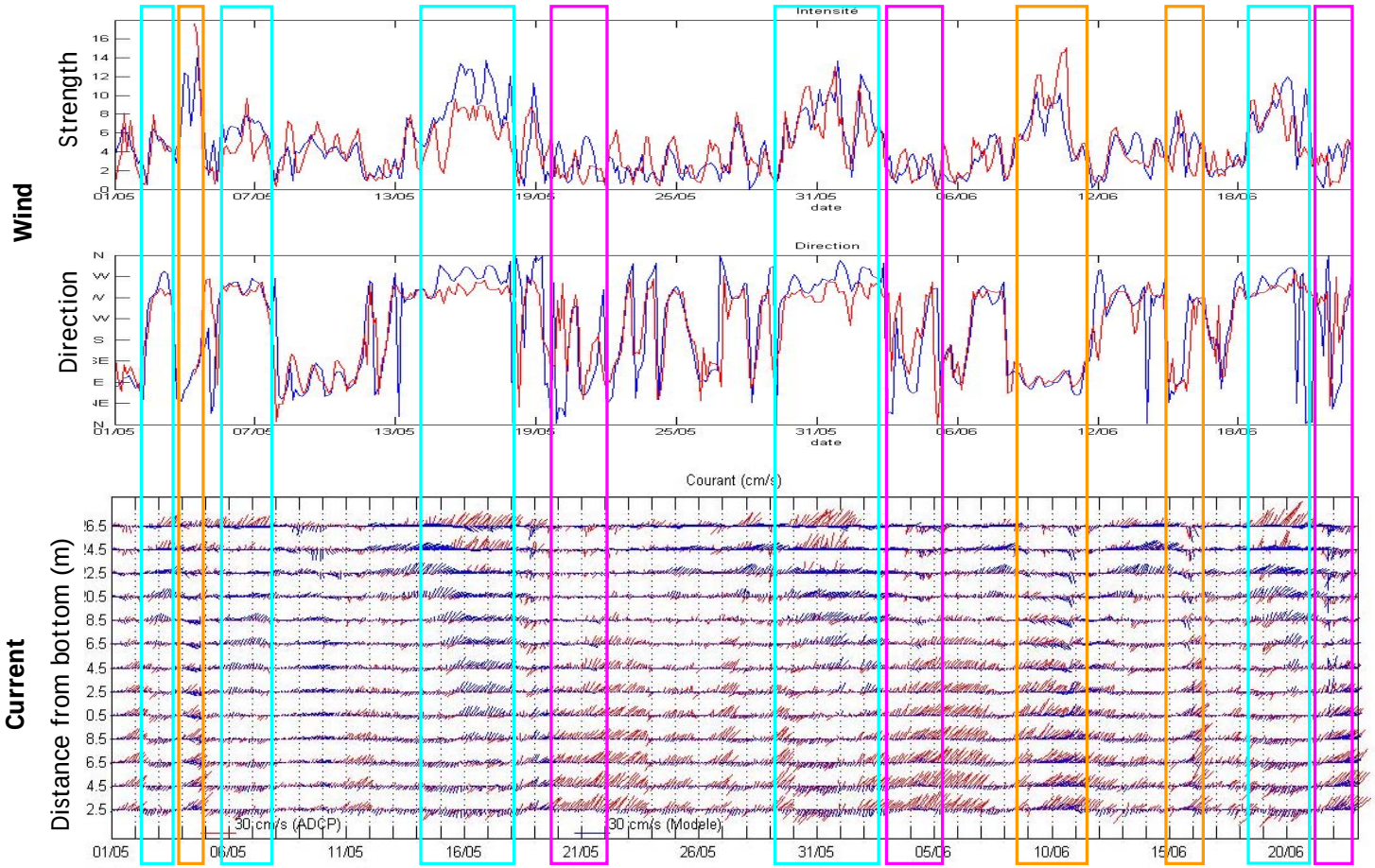
Fall 2009

Measured

Model results

Current strength underestimated

Model / ADCP measures comparison



Spring 2010

Measured

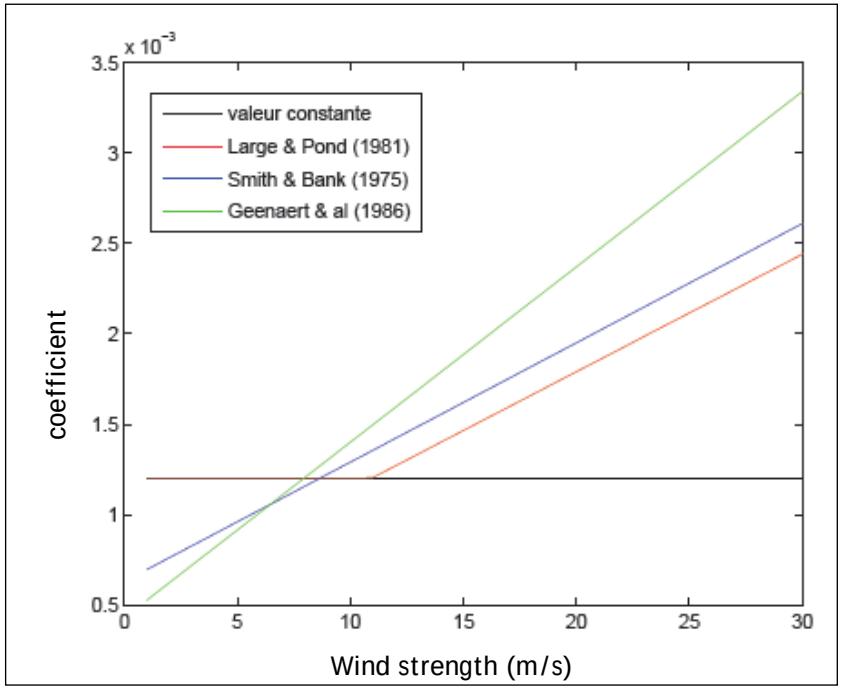
Model results

Current strength underestimated

West wind (Mistral) East wind Leek wind (<5m/s)

Modification of model parameters

Surface drag coefficient



(Schaeffer, 2010)

Summer 2009

Drag coefficient	Model current u	Model current v	Model current Strength
Large & Pond $Cd = 10^{-3}(0.49+0.065U)$ if $U>10ms^{-1}$, else $Cd=1.2*10^{-3}$	Cor = 0.83 Bias = 6.2 RMSE = 7.3	Cor = 0.73 Bias = 2.1 RMSE = 6.2	Cor = 0.76 Bias = -7.6 RMSE = 8.3
Smith & Bank $Cd = 10^{-3}(0.63+0.066U)$	Cor = 0.82 Bias = 5.8 RMSE = 6.9	Cor = 0.75 Bias = 4.3 RMSE = 7.1	Cor = 0.79 Bias = -7.4 RMSE = 8.3
Geenaert & al. $Cd = 10^{-3}(0.43+0.097U)$	Cor = 0.82 Bias = 5.7 RMSE = 6.9	Cor = 0.75 Bias = 4.4 RMSE = 7.2	Cor = 0.78 Bias = -7.4 RMSE = 8.4

Impact surface drag coefficient < impact meteorological forcing